Effects of a proprioceptive physical exercise program on balance in young skaters aged between 11 to 15 years

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Summary

Introduction: Having an adequate state of body balance allows the skater to maintain an adequate technique and control in the execution of each sporting gesture, this may limit accessory movements that lead to an inadequate increase in joint stress, which can ultimately impact on the health status and performance of these athletes.
Aim: To determine the effects of a proprioceptive physical exercise program on balance in skaters between the ages of 11 and 15 years.
Methodology: A experimental study conducted in 58 skaters belonging to the Santander Skating League of Bucaramanga, who were randomized into two groups, one received proprioceptive training (n = 29) and the other group performed a conventional training (n = 29), both were developed for 12 weeks with a frequency of 3 times a week and a duration per session of 30 minutes.
Results: The dynamic balance assessed with the Star Excursion Balance Test (SEBT), showed changes in all directions after the intervention of both groups. In relation to the static balance determined with the Balance Error Scoring System (BESS) showed positive changes in the experimental group.
Conclusions: The proprioceptive training program produces results superior to the conventional one, in terms of the static and dynamic balance of the skaters evaluated.

Key words:
Postural balance. Skating. Propioception.

Efectos de un programa de ejercicio físico propioceptivo sobre el equilibrio en jóvenes patinadores entre los 11 y 15 años

Resumen

Introducción: Un estado de equilibrio corporal apropiado permite al patinador mantener el control y la técnica adecuada en la ejecución de cada gesto deportivo. Así, un buen estado reduce movimientos accesorios que llevan al deportista a un incremento del estrés articular, que finalmente puede repercutir en el estado de salud y el rendimiento de estos atletas.
Objetivo: Determinar el efecto de un programa de ejercicio físico propioceptivo sobre el equilibrio de patinadores en edades comprendidas entre los 11 a 15 años.
Material y método: Estudio experimental con dos grupos de intervención en paralelo, realizado en 58 deportistas pertenecientes a la Liga Santandereana de Patinaje de la ciudad de Bucaramanga, quienes fueron aleatorizados en dos grupos: Grupo Experimental (GE) (n=29) que recibió entrenamiento propioceptivo y Grupo Control (GC) (n=29) que recibió entrenamiento convencional. Ambos protocolos fueron desarrollados durante doce (12) semanas, con una frecuencia de tres veces por semana y una duración de treinta minutos en cada sesión. El equilibrio dinámico y estático fue evaluado antes y después de cada intervención mediante *Star Excursion Balance Test* (SEBT) y *Balance Error Scoring System* (BESS).
Resultados: Después de la intervención, ambos grupos mostraron cambios positivos en cuanto al equilibrio dinámico; éstos fueron superiores en el GE (p<0.05). En cuanto al equilibrio estático, los cambios fueron positivos y significativos en el grupo que recibió ejercicio propioceptivo (p<0.05). En contraste, el grupo que recibió tratamiento convencional no mostró cambios en esta variable.
Conclusión: El entrenamiento propioceptivo produce resultados superiores en el equilibrio estático y dinámico de los patinadores evaluados, en comparación con los resultados generados por el entrenamiento convencional.

Palabras clave:
Equilibrio postural. Patinaje. Propiocepción.

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Introduction

Skating requires athletes to adapt their body to a specific, unnatural movement, in which the point of support is reduced. Therefore, their support is based on four fixed, inline wheels that slide over a surface, drawing a straight line that is at an oblique angle to forward movement; this condition produces continuous changes of balance thereby causing a greater degree of instability compared to other sports[1].

Indeed, balance is the basic component in skating because it makes it possible to maintain an adequate technique and control in the execution of each sports gesture and, moreover, it limits the accessory movements that increase joint stress[1-4]. The correct technique for roller speed skating is based on achieving maximum effectiveness and efficiency of the forces applied to the skate during the push, slide and recovery phases[5,6]. Indeed, the lack of good postural balance may lead to the wasteful use of these forces due to inefficient movements that finally affect sporting performance[2,7-14].

Today, proprioceptive work is not always considered in sports training processes, particularly in speed skating; in most cases, its importance is stressed as a rehabilitation tool. Studies indicate that this type of work permits more effective movement and offers athletes a greater reaction capacity against competition demands. This fact may suggest that a proprioceptive exercise program is an important factor in the planning and methodological processes of sports training[15-17].

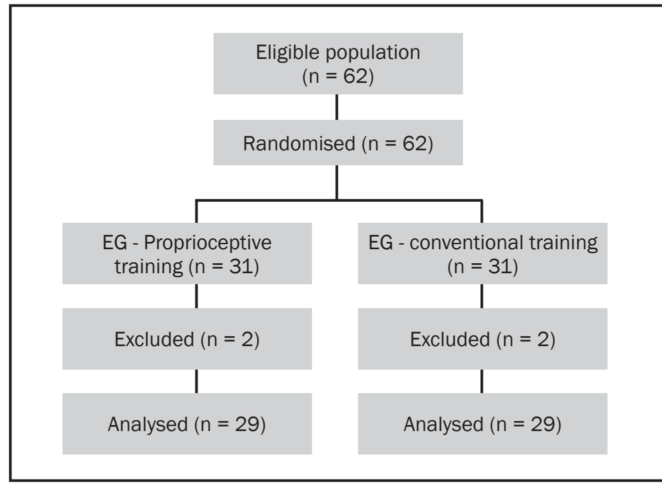
Added to the above, the little scientific evidence related to the effects of proprioceptive work on the balance of skaters, justifies the conduct of this study.

Material and method

This experimental study was conducted with two parallel intervention groups, comprising 58 skaters pertaining to the Santandereana Skating League of the city of Bucaramanga, aged between 11 to 15 years. The athletes were randomised into two groups: the first one, the Experimental Group (EG) received a proprioceptive physical exercise program; while the second one, the Control Group (CG) was given conventional training. The protocols for the two groups were implemented over 12 weeks with a frequency of 3 times per week and a duration of 30 minutes per session. On the other hand, the dynamic and static stability assessments were conducted before and after the exercise program. It should also be indicated that four subjects were excluded from the study, due to musculoskeletal injuries (Figure 1).

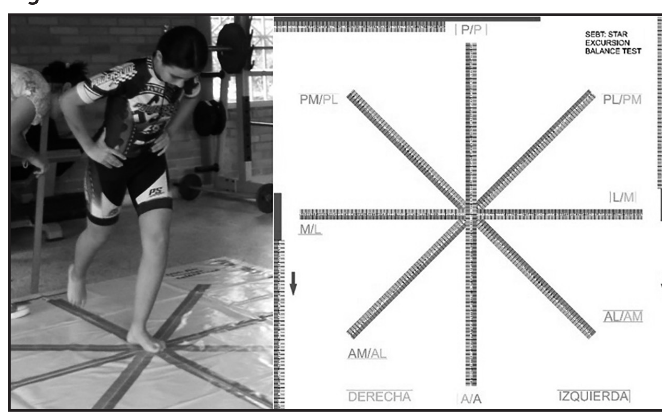
In relation to the dynamic balance evaluation, this was conducted with the aid of the *Star Excursion Balance Test* (SEBT) which has shown a reliability of between 0.85 and 0.96[18]. For this test, the subject stands in the middle of a 1.83 m x 1.83 m square marked out with tape on the floor and comprising 8 lines in the form of a star with an intersection angle of 45º between each line from the centre of the square[19]. These lines are named according to the direction of reach in relation to the stance leg:

Figure 1. Flow diagram, data collection.



Source: Compiled by author.

Figure 2. Star Excursion Balance Test.



(AL), anterior (A), anteromedial (AM), medial (M), posteromedial (PM), posterior (P), posterolateral (PL), y lateral (L)[20] (Figure 2).

In this test, the subject is positioned in the centre of the star, maintaining a single-leg stance. Immediately the unsupported leg must make a light touch for a 1 second duration as far as possible on each of the marked lines, in a clockwise direction for an unsupported right leg and in an anti-clockwise direction for the left leg. Three complete attempts were permitted with a 3 minute interval between each one. The distance achieved in each direction was the average of the 3 attempts[20].

On the other hand, the assessment of the static body balance was made with the *Balance Error Scoring System* (BESS), which has shown good reliability in paediatric and adolescent populations[21]. This comprises three stances on two different surfaces: one firm and the other foam. Subjects are barefoot and must place their hands on their iliac crests, and position themselves in three different stances, namely double-leg, single-leg and tandem (one foot behind the other)[22].

In the first stance, the feet must be resting on the surface and approximately hip-width distance apart, the single leg stance should be made with the non-dominant side with 20 degrees of hip flexion and 45 degrees of knee flexion. Finally, in the tandem stance, the subject must stand with the non-dominant foot at the back. Each stance must be held for 20 seconds with the eyes closed. The evaluator must count the athlete's errors or deviations from the correct stance as follows: 1) Hands lifted off the iliac crest 2) Opening eyes 3) Step, stumble or fall. 4) Moving hip into more than 30 degrees abduction. 5) Lifting forefoot or heel. 6) Remaining out of the test position more than 5 seconds. To record the result, the number of errors committed in each of the three stances are added together. The maximum total number of errors is 10. The greater the number of errors, the poorer the balance[23].

Interventions

Experimental group

The application of the proprioceptive exercise is based on the program proposed by Avalos, Mancera and Adalid[24-26], making some changes to tailor it to the demands of speed skating. The program was designed to be applied in a pre-competitive period and comprised single- and double-leg stances on stable and unstable surfaces with the eyes open and closed. With a 12-week duration, it comprised a general mesocycle of 5 weeks and a specific one of 7 weeks, to be performed three times a week with a duration of 30 minutes for each session.

At each session, a 10' warm-up was performed, followed by five proprioception exercises developed at 8 levels: for the first level, the subjects kept their eyes open, with a double leg stance on a firm, stable surface with a wide base of support. For the second level, their eyes must remain closed, the athletes remained in a double leg stance on a firm surface and with a reduced base of support. For the third level, the exercises were performed with their eyes open, single leg stance on an unstable, horizontally positioned board. For the fourth level, the exercises were performed with their eyes open, single leg stance on an unstable, vertically positioned board. For the fifth level, the single leg stance was maintained and the exercises were performed with their eyes closed on an unstable, horizontally positioned board. The sixth level corresponds to a single leg stance, eyes closed on an unstable, vertically positioned board. And, finally, for the seventh and eighth levels, the tests were conducted on skates with the eyes open and closed respectively.

From the third to the eighth levels, external disturbances were performed, including arm movements, simulating the movement made when skating, movement with a fellow athlete and the use of an air balloon. The dynamic stability exercise was performed with progressively higher jumps - first 5 centimetres, then 10 centimetres and finally 15 centimetres. Finally, a dynamic stretching routine was performed.

Control group

This group performed a conventional warm-up imposed by the skating trainer, at the start of the training session, consisting in continuous jogging, jumps at different heights and directions, as well as muscle stretching.

Statistical analysis

The data analysis was performed with the SPSS statistics program, version 20.0 licensed by the Universidad Autónoma de Manizales. The normality distribution was determined through the Kolmogorov – Smirnov test. This was then used to calculate the measures of the central tendency and dispersion for the quantitative variables, as well as the absolute and relative frequencies for the qualitative variables. The Student's t test for independent data was used to compare the difference between the measurements for the two groups. The comparison of the dynamic and static stability change, before and after the exercise program, was made according to the distribution of variables, by a Student *t* test or Wilcoxon rank test. In general, an alpha level of 5% was considered for the entire analysis.

Ethical considerations

The study was approved by the Ethics Committee of the Universidad Autónoma de Manizales. Participants gave their voluntary acceptance and signed the informed consent. Likewise, the study was classified as minimum risk according to resolution 008430 of 1993 of the Ministry of Heath of Colombia, in addition to the fact that the study observed the ethical principles of research on human beings.

Results

Table 1 shows that the mean age was 12.93±1.4 years and 13.21±1.3 for the Experimental and Control groups respectively. With regard to Body Mass Index (BMI), this was 18.25 kg/m^2 ± 2.1 kg/m^2, for the EG and 19.75 ± 4.0 kg/m^2 for the CG. 69% of the population studied were females and 67% were distance skaters.

Table 2 shows an improvement in the dynamic balance in all directions for both groups ($p<0.05$). The greatest differences were observed to be in the the following directions: left posterior (12.51 cm), right (11.79 cm) and left posteromedial (11.93 cm) of the EG.

After the intervention on the EG, an improvement was observed in the static balance averages on a firm, stable surface (Table 3). For its part, although the CG showed changes for both surfaces, the results are not statistically significant.

Discussion

The results of this study suggest that proprioceptive training, made with youth skaters, gives better static and dynamic balance results compared to those achieved with conventional training. These positive effects generated by proprioceptive training have principally been confirmed in other sports such as football, basketball and handball[3].

It should be pointed out that few investigations have been made in the field of roller skating and those that have been made are focussed on describing anthropometric characteristics and on the kinematic analysis of the push cycles in youth skaters[27-31]. On the other hand, studies have been made on speed or figure ice skating, which are also directed at

Table 1. Sociodemographic characteristics of the participants in the study.

Variables		Experimental Group (n=29)		Control Group (n=29)	
Age		12.93 ± 1.4		13.21 ±1.3	
Height (cm)		155.6 ± 10.38		158.3 ± 8.73	
Weight (kg)		44.96 ± 7.4		48.27 ± 8.0	
BMI (kg/m2)		18.25 ± 2.1		19.75 ± 4.0	
		Experimental group (n=29)		Control group (n=29)	
		Frequency	Percentage	Frequency	Percentage
Sex	Male	12	41.4 %	6	20.7 %
	Female	17	58.6 %	23	79.3 %
Sports discipline	Speed	9	31 %	10	34.5 %
	Distance	20	69 %	19	65.5 %

Source: Compiled by author

Table 2. Initial and final dynamic balance in the experimental and control groups.

SEBT TEST								
Direction	Laterality	Group	Initial		Final		Dif.	p
			Average	(SD)	Average	(SD)		
Ant	Right	Experimental	69.45 cm	6.74	75.00 cm	6.87	5.55	0.000*
		Control	68.83 cm	6.43	74.28 cm	5.73	5.45	0.000*
	Left	Experimental	70.45 cm	7.24	76.07 cm	6.011	5.62	0.000*
		Control	69.59 cm	7.12	74.76 cm	6.71	5.17	0.000*
Ant-lat	Right	Experimental	72.17 cm	6.61	78.69 cm	6.69	6.52	0.000*
		Control	71.90 cm	7.78	77.21 cm	6.68	5.31	0.000*
	Left	Experimental	73.24 cm	8.42	79.31 cm	6.13	6.07	0.000*
		Control	73.48 cm	6.73	77.59 cm	7.36	4.11	0.000*
Lat	Right	Experimental	72.90 cm	8.80	81.62 cm	7.59	8.72	0.000*
		Control	73.00 cm	7.18	79.66 cm	7.75	6.66	0.000*
	Left	Experimental	74.38 cm	9.91	80.97 cm	7.34	6.59	0.000*
		Control	74.10 cm	7.82	79.69 cm	8.18	5.59	0.000*
Post-lat	Right	Experimental	73.48 cm	10.43	83.17 cm	8.64	9.69	0.000*
		Control	74.21 cm	7.97	81.66 cm	7.91	7.45	0.000*
	Left	Experimental	73.76 cm	12.06	83.28 cm	7.79	9.52	0.000*
		Control	74.69 cm	9.27	82.28 cm	8.13	7.59	0.000*
PostRight	Right	Experimental	70.83 cm	12.40	82.62 cm	9.64	11.79	0.000*
		Control	74.00 cm	10.20	83.03 cm	8.52	9.03	0.000*
	Left	Experimental	70.83 cm	12.97	83.34 cm	10.38	12.51	0.000*
		Control	73.76 cm	9.23	82.83 cm	8.13	9.07	0.000*
Post-med	Right	Experimental	66.62 cm	12.19	76.34 cm	10.26	9.72	0.000*
		Control	68.28 cm	8.78	74.21 cm	7.87	5.93	0.000*
	Left	Experimental	66.14 cm	13.70	78.07 cm	9.43	11.93	0.000*
		Control	68.45 cm	9.37	74.31 cm	8.58	5.86	0.000*
MedRight	Right	Experimental	60.45 cm	12.74	67.45 cm	10.44	7.00	0.000*
		Control	61.76 cm	8.58	67.00 cm	7.48	5.24	0.000*
	Left	Experimental	59.59 cm	12.34	69.14 cm	9.47	9.55	0.000*
		Control	60.72 cm	9.45	65.90 cm	7.87	5.18	0.000*
Ant-med	Right	Experimental	65.52 cm	7.98	70.79 cm	5.72	5.27	0.000*
		Control	65.62 cm	6.50	69.72 cm	5.87	4.10	0.001*
	Left	Experimental	66.55 cm	9.716	71.55 cm	5.18	5.00	0.001*
		Control	65.41 cm	6.31	69.72 cm	5.99	4.31	0.002*

Source: Compiled by author (*p <0.05)

Table 3. Initial and final static balance in the experimental and control groups.

Variable	Group	BESS TEST Initial Average	Initial SD	Final Average	Final SD	Dif.	p
BESS firm	Experimental	8.03 points	5.68	5.21 points	4.32	2.82	0.015*
	Control	6.14 points	4.31	5.24 points	4.65	0.9	0.455*
BESS foam	Experimental	14.69 points	4.84	11.97 points	5.14	2.72	0.040*
	Control	12.00 points	5.06	10.17 points	5.85	1.73	0.253*

Source: Compiled by author (*p <0.05)

showing the effect of proprioceptive training on postural control as well as physical performance and ankle stability[9,26,32-36].

The interest in analysing the influence of balance training on youth skaters is based on the fact that, at these ages, the skills of proprioception (sense of position) and praxis (sense of space) are immature. This characteristic causes these athletes to be more vulnerable to falls and injuries, primarily with regard to the ankle, where the resistance of the ligaments is physiologically reduced at this stage in life[37,38].

Brachman *et al.* consider some of the results of the studies showing the influence of proprioceptive training on physical performance, postural control and injury prevention to be controversial. However, Akahame *et al.* demonstrate that the training performed on unstable surfaces and even on the actual skates, as in our study, improves postural control and the strength of the lower limbs. In this way, these effects could reduce the risk of injury and increase the competitiveness of the athlete[2].

The work of Brachman *et al.* as well as that of Heitkamp *et al.* and Hrysomallis, conclude that the relationship between the athlete's level of balance, the number of injuries and sporting results, has not been sufficiently understood. This is due to the fact that there is no agreement between the results of the studies and there is no wide body of research in this area. Despite the above, the investigators suggest that proprioceptive training could manage to improve the competitiveness and reduce the risk of injury when it is adequately directed, even when combined with strength training it could manage to increase its effectiveness[2,3,14,34].

In their review, Brachman *et al.* conclude that the positive effect of proprioceptive training on athletes in different disciplines, aged between 7 and 30 years, was more effective when the exercise protocols had a duration of between 8 to 12 weeks, with a frequency of two sessions per week and a time of 45 minutes per session; this routine is similar to the one used in our study. On the other hand, most articles analysed by Brachman *et al.* use the SEBT and the BESS to assess balance, as in our study. These tests are considered to be versatile and with suitable psychometric properties in the child and youth population[18-21].

It should be pointed out that the results shown by Brachman *et al.* do not include any articles analysing speed skaters, they only include the study by Saunders *et al.* which analyses the effect of proprioceptive training on youth figure skaters. However, this does not show any significant changes following a program of three sessions per week over six weeks. This latter characteristic may be a reason for which the exercise protocol used does not evidence an improvement in corporal balance[26]. The above statement may be based on the results evidenced by Winter *et al.*, who found that a five session training program over twelve weeks, and not during six, creates changes in the speed skater's balance. However, Kovac *et al.* mention that a four week training schedule, with three proprioceptive exercise sessions can improve the postural control of young figure skaters[35-36].

With regard to the above, it is important to consider the complexity of establishing an appropriate training model for each sports discipline and type, including its characteristics and demands. Moreover, there are other factors that could affect the results obtained after the planned training. One of these is the balance level of the skater before starting training and which was not measured in all the studies[38].

Conclusion

This is the first experimental work conducted on speed roller skaters; here it is evidenced that proprioceptive training conducted three times a week with a duration of 30' per session, over twelve weeks, improves the dynamic and static balance of these athletes. This suggests the inclusion of exercises of this type as a key factor in the training planning and methodology for roller skaters. On the other hand, it is relevant to point out that this training must be differentiated and adapted to the specific type of sport, as was done in this study. Finally, we would suggest that future studies analyse the effect of this training routine on physical performance and the risk of injuries in subjects pertaining to the different categories and types of roller skating.

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Conflict of interest

The authors do not declare a conflict of interest.

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